



**THIRUVALLUVAR UNIVERSITY**  
**SERKKADU, VELLORE-632115**

# **M.SC. BIOCHEMISTRY**

**SYLLABUS**

**FROM THE ACADEMIC YEAR**  
**2023 – 2024**

<b>Programme:</b>	<b>M.Sc BIOCHEMISTRY</b>
<b>Programme Code:</b>	<b>LIFC</b>
<b>Duration:</b>	<b>2 years</b>

<b>Programme Outcomes:</b>	<p><b>PO1.</b> To make students understand the importance of biochemistry as a subject that deals with life processes, as well as the concepts, theories and experimental approaches followed in biochemistry, in order to pursue a research career, either in an industry or academic setting.</p> <p><b>PO2.</b> To develop analytical and problem-solving skills</p> <p><b>PO3.</b> To create an awareness among the students on the interconnection between the interdisciplinary areas of biochemistry.</p> <p><b>PO4.</b> To give the necessary practical skills required for biochemical techniques and analysis.</p> <p><b>PO5.</b> To develop a communication and writing skills in students.</p> <p><b>PO6.</b> To develop leadership and teamwork skills</p> <p><b>PO7.</b> To emphasize the importance of good academic and work ethics and their social implications.</p> <p><b>PO8.</b> To emphasize the importance of continuous learning and to promote lifelong learning and career development.</p> <p><b>PO9.</b> To teach students how to retrieve information from a variety of sources, including libraries, databases and the internet.</p> <p><b>PO10.</b> To teach students to identify, design and execute a research problem, analyze and interpret data and learn time and resource management.</p>
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<p><b>Programme Specific Outcomes:</b></p>	<p><b>Programme Specific Outcomes (PSO)</b></p> <p><b>On successful completion of this course, students should be able to:</b></p> <p><b>PSO1.</b> Understand the principles and methods of various techniques in Biochemistry, Immunology, Microbiology, Enzyme kinetics and Molecular Cell Biology. Based on their understanding, the students may would be able to design and execute experiments during their final semester project, and further research programs.</p> <p><b>PSO2.</b> Insight on the structure-function relationship of biomolecules, their synthesis and breakdown, the regulation of these pathways, and their importance in terms of clinical correlation. Students will also acquire knowledge of the principles of nutritional biochemistry and also understand diseases and their prevention.</p> <p><b>PSO3.</b> To understand the concepts of cellular signal transduction pathways and the association of aberrant signal processes with various diseases. Acquire insight into the immune system and its responses, and use this knowledge in the processes of immunization, vaccine development, transplantation and organ rejection.</p> <p><b>PSO4.</b> To visualize and appreciate the central dogma of molecular biology, regulation of gene expression, molecular techniques used in rDNA technology, gene knock-out and knock-in techniques.</p> <p><b>PSO5.</b> To create awareness in students about the importance of good laboratory practices and the importance of ethical and social responsibilities of a researcher. Teach them how to review literature and the art of designing and executing experiments independently and also work as a part of a team.</p>
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**Total Credit Points -91**

**Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum  
Framework (LOCF) Guideline Based Credits and Hours Distribution System  
for all Post – Graduate Courses including Lab Hours**

**First Year – Semester – I**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – I	5	7
	Core – II	5	7
	Core – III	4	6
	Elective – I	3	5
	Elective – II	3	5
		<b>20</b>	<b>30</b>

**Semester-II**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – IV	5	6
	Core – V	5	6
	Core – VI	4	6
	Elective – III	3	4
	Elective – IV	3	4
	Skill Enhancement Course [SEC] - I	2	4
		<b>22</b>	<b>30</b>

**Second Year – Semester – III**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – VII	5	6
	Core – VIII	5	6
	Core – IX	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course - II	2	3
	Internship / Industrial Activity [Credits]	2	-
		<b>26</b>	<b>30</b>

**Semester-IV**

<b>Part</b>	<b>List of Courses</b>	<b>Credits</b>	<b>No. of Hours</b>
	Core – XI	5	6
	Core – XII	5	6
	Project with VIVA VOCE	7	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		<b>23</b>	<b>30</b>

**Total 91 Credits for PG Courses**

**List of Courses:**

<b>Semester</b>	<b>Title of the Course</b>	<b>Core/Elective/ Soft Skill</b>	<b>Credits</b>	<b>Tutorial Hours</b>
<b>I</b>	Basics of Biochemistry	Core- I	5	7
	Biochemical and Molecular Biology Techniques	Core - II	5	7
	Laboratory course on Biomolecules and Biochemical Techniques	Core Practical I	4	6
	Microbiology & Immunology	Elective – I	3	5
	Energy and drug metabolism	Elective – II	3	5
			<b>20</b>	<b>30</b>

\* Internship will be carried out during the summer vacation of the first year and marks should be sent to the University by the College and the same will be included in the Third Semester Marks Statement.

### SEMESTER I

<b>Course</b>	<b>CORE PAPER I</b>
<b>Title of the Course:</b>	<b>BASICS OF BIOCHEMISTRY</b>
<b>Credits:</b>	<b>5</b>
<b>Pre-requisites, if any:</b>	Basic Knowledge of Biochemistry and Biomolecules
<b>Course Objectives</b>	<p>The main objectives of this course are to:</p> <ol style="list-style-type: none"> <li>1. Students will be introduced to the structure of biomolecules.</li> <li>2. The significance of carbohydrates in biological processes will be understood.</li> <li>3. The structure, properties and biological significance of lipids in the biological system will be studied</li> <li>4. Students will learn about the concepts of protein structure and their significance in biological processes and creatively comprehend the role of membrane components with their biological significance.</li> <li>5. Students will gain knowledge about the structures and functional roles of nucleic acids in the biological system</li> </ol>
<b>Course Outcomes</b>	<p>On successful completion of the course, the students should be able to:</p> <p><b>CO1 :</b> Explain the chemical structure and functions of carbohydrates. (K1, K2)</p> <p><b>CO2:</b> Using the knowledge of lipid structure and function, explain how it plays a role in Signalling pathways ( K3,K4)</p> <p><b>CO3:</b> Describe the various levels of structural organisation of proteins and the role of proteins in biological system (K4, K5)</p> <p><b>CO4:</b> Apply the knowledge of proteins in cell-cell interactions.(K3,K4)</p> <p><b>CO5.</b> Applying the knowledge of nucleic acid sequencing in research and diagnosis (K2, K3,K4)</p>



Units	
<b>I</b>	Carbohydrates- Classification, structure (configurations and conformations, anomeric forms), function and properties of monosaccharides, mutarotation, Disaccharides and oligosaccharides with suitable examples . Polysaccharides - Homopolysaccharides (starch, glycogen, cellulose, inulin, dextrin, agar, pectin, dextran). Heteropolysaccharides - Glycosaminoglycans– source, structure, functions of hyaluronic acid, chondroitin sulphates, heparin, keratan sulphate,. Glycoproteins - proteoglycans. O- Linked and N-linked glycoproteins. Biological significance of glycan. Blood group polysaccharides. Bacterial cell wall (peptidoglycans, teichoic acid) and plant cell wall carbohydrates.
<b>II</b>	Lipids – Classification of lipids, structure, properties and functions of fatty acids, triacylglycerols, phospholipids, glycolipids, sphingolipids and steroids – Biological importance. Eicosanoids- classification, structure and functions of prostaglandins, thromboxanes, leukotrienes. Lipoproteins – Classification ,structure, transport ( endogenous and exogenous Pathway ) and their biological significance.
<b>III</b>	Overview of Aminoacids - classification, structure and properties of amino acids, Biological role.Non Protein aminoacids and their biological significance .Proteins – classification based on composition, structure and functions. Primary, secondary, super secondary (motifs) (Helix-turn –helix, helix-loop-helix, Beta-alpha-beta motif),tertiary and quaternary structure of proteins. Structural characteristics of collagen and hemoglobin. Determination of amino acid sequence.Chemical synthesis of a peptide, Forces involved in stabilization of protein structure. Ramachandran plot. Folding of proteins. Molecular chaperons – Hsp 70 and Hsp 90 - biological role.
<b>IV</b>	Membrane Proteins - Types and their significance. Cytoskeleton proteins - actin , tubulin , intermediate filaments . Biological role of cytoskeletal proteins. Membrane structure-fluid mosaic model

<b>V</b>	Nucleic acids – types and forms (A, B, C and Z) of DNA. Watson-Crick model-Primary, secondary and tertiary structures of DNA. Triple helix and quadruplex DNA. Mitochondrial and chloroplast DNA. DNA supercoiling (calculation of Writhe, linking and twist number). Determination of nucleic acid sequences by Maxam Gilbert and Sanger's methods. Forces stabilizing nucleic acid structure. Properties of DNA and RNA. C-value, C-value paradox, Cot curve.. Major and minor classes of RNA, their structure and biological functions.
<b>Reading List (Print and Online)</b>	<ol style="list-style-type: none"> <li>1. <a href="https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry_Online_(Jakubowski)">https://bio.libretexts.org/Bookshelves/Biochemistry/Book%3A_Biochemistry_Online_(Jakubowski)</a></li> <li>2. <a href="https://www.thermofisher.com/in/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/pierce-protein-methods/protein-glycosylation.html">https://www.thermofisher.com/in/en/home/life-science/protein-biology/protein-biology-learning-center/protein-biology-resource-library/pierce-protein-methods/protein-glycosylation.html</a></li> <li>3. <a href="https://ocw.mit.edu/courses/biology/7-88j-protein-folding-and-human-disease-spring-2015/study-materials/">https://ocw.mit.edu/courses/biology/7-88j-protein-folding-and-human-disease-spring-2015/study-materials/</a></li> <li>4. <a href="https://www.open.edu/openlearn/science-maths-technology/science/biology/nucleic-acids-and-chromatin/content-section-3.4.2">https://www.open.edu/openlearn/science-maths-technology/science/biology/nucleic-acids-and-chromatin/content-section-3.4.2</a></li> <li>5. <a href="https://www.genome.gov/genetics-glossary/Cell-Membrane">https://www.genome.gov/genetics-glossary/Cell-Membrane</a> <a href="https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod3.pdf">https://nptel.ac.in/content/storage2/courses/102103012/pdf/mod3.pdf</a></li> </ol>
<b>Self-Study</b>	<ol style="list-style-type: none"> <li>1. Classification of Sugars</li> <li>2. Nutritional classification of fatty acids</li> </ol>
<b>Recommended Texts</b>	<ol style="list-style-type: none"> <li>1. David L.Nelson and Michael M.Cox (2012) Lehninger Principles of Biochemistry (6th ed) W.H. Freeman.</li> <li>2. Voet.D &amp; Voet. J.G (2010) Biochemistry , (4th ed), John Wiley &amp; Sons, Inc.</li> <li>3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press.</li> <li>4. Zubay G.L (1999) Biochemistry , (4th ed), Mc Graw-Hill.</li> <li>5. Lubert Stryer (2010) Biochemistry,(7th ed), W.H.Freeman</li> <li>6. Satyanarayan,U (2014) Biochemistry (4th ed), Arunabha Sen Books &amp; Allied (P) Ltd, Kolkata.</li> </ol>

**Method of Evaluation:**

Test I	Test II	Assignment	End Semester Examination	Total
10	10	5	75	100

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse(K4)** – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas.

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons

**Create (K6)** – Check knowledge in specific or offbeat situations. Discussion.

**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
<b>CO 1</b>	<b>S</b>	<b>L</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>
<b>CO 2</b>	<b>S</b>	<b>M</b>	<b>L</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>
<b>CO 3</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>L</b>	<b>S</b>	<b>M</b>	<b>M</b>
<b>CO 4</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>
<b>CO 5</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>

**S- Strong**

**M-Medium**

**L-Low**

**Strong:18**

**Medium: 29**

**Low:3**

<b>Course</b>	<b>CORE PAPER II</b>
<b>Title of the Course:</b>	<b>BIOCHEMICAL AND MOLECULAR BIOLOGY TECHNIQUES</b>
<b>Credits:</b>	<b>5</b>
<b>Pre-requisites, if any:</b>	Comprehensive Knowledge of Tools of Biochemistry/Molecular Biology
<b>Course Objectives</b>	<p>Biochemical techniques combine various inter-disciplinary methods in biological research and the course aims to provide students with the following objectives:</p> <ol style="list-style-type: none"> <li>1. To understand the various techniques used in biochemical investigation and microscopy.</li> <li>2. To explain chromatographic techniques.\ and their applications</li> <li>3. To explain electrophoretic techniques.</li> <li>4. To comprehend the spectroscopic techniques and demonstrate their applications in biochemical investigations.</li> <li>5. To acquire knowledge of radio labelling techniques and centrifugation.</li> </ol>
<b>Course Outcomes</b>	<p>After completion of the course, the students should be able to:</p> <p><b>CO1.</b> Attain good knowledge in modern used in biochemical investigation and microscopy and apply the experimental protocols to plan and carry out simple investigations in biological research. (K1, K5)</p> <p><b>CO2.</b> Demonstrate knowledge to implement the theoretical basis of chromatography in upcoming practical course work. (K3, K5)</p> <p><b>CO3.</b> Demonstrate knowledge to implement the theoretical basis of electrophoretic techniques in research work. (K3, K5)</p> <p><b>CO4.</b> Tackle more advanced and specialized spectroscopic techniques that are pertinent to research. (K1, K2 &amp; K5)</p> <p><b>CO5.</b> Tackle more a dvanced and specialized radioisotope and centrifugation techniques that are pertinent to research work. (K1, K2 &amp; K5)</p>
<b>Units</b>	

<b>I</b>	General approaches to biochemical investigation, cell culture techniques and microscopic techniques. Organ and tissue slice technique, cell distribution and homogenization techniques, cell sorting, and cell counting, tissue Culture techniques. Cryopreservation, Biosensors- principle and applications. Principle, working and applications of light microscope, dark field, phase contrast and fluorescent microscope. Electron microscope-Principle, instrumentation of TEM and SEM, Specimen preparation and applications-shadow casting, negative staining and freeze fracturing.
<b>II</b>	Chromatographic Techniques: Basic principles of chromatography- adsorption and partition techniques. Chiral Chromatography and counter current Chromatography. Adsorption Chromatography – Hydroxy apatite chromatography and hydrophobic interaction Chromatography. Affinity chromatography. Gas liquid chromatography- principle, instrumentation, column development, detectors and applications. Low pressure column chromatography – principle, instrumentation, column packing, detection, quantitation and column efficiency, High pressure liquid chromatography- principle, instrumentation, delivery pump, sample injection unit, column packing, development, detection and application. Reverse HPLC, capillary electro chromatography and perfusion chromatography.
<b>III</b>	Electrophoretic Techniques: General principles of electrophoresis, supporting medium, factors affecting electrophoresis, Isoelectric focusing-principle, ampholyte, development of pH gradient and application. PAGE-gel casting-horizontal, vertical, slab gels, sample application, detection-staining using CBB, silver, fluorescent stains. SDS PAGE-principle and application in molecular weight determination principle of disc gel electrophoresis ,2D PAGE. Electrophoresis of nucleic acids-agarose gel electrophoresis of DNA, pulsed field gel electrophoresis- principle, apparatus, application. Electrophoresis of RNA, curve. Microchip electrophoresis and 2D electrophoresis, Capillary electrophoresis.
<b>IV</b>	Spectroscopic techniques: Basic laws of light absorption- principle, instrumentation and applications of UV-Visible, IR, ESR, NMR, Mass spectroscopy, Turbidimetry and Nephelometry. Luminometry (Luciferase system, chemiluminescence). X - ray diffraction. Atomic absorption spectroscopy - principle and applications - Determination of trace elements

<b>V</b>	<p>Radiolabeling Techniques and Centrifugation:</p> <p>Nature of radioactivity-detection and measurement of radioactivity, methods based upon ionisation (GM counter) and excitation (scintillation counter), autoradiography and applications of radioactive isotopes, Biological hazards of radiation and safety measures in handling radioactive isotopes.</p> <p>Basic principles of Centrifugation. Preparative ultracentrifugation - Differential centrifugation, Density gradient centrifugation. Analytical ultracentrifugation - Molecular weight determination.</p>
<b>Reading List (Print and Online)</b>	<p>Principles and techniques of biochemistry and molecular biology: <a href="https://www.kau.edu.sa/Files/0017514/Subjects/principals%20and%20techniques%20of%20biochemistry%20and%20molecular%20biology%207th%20ed%20">https://www.kau.edu.sa/Files/0017514/Subjects/principals%20and%20techniques%20of%20biochemistry%20and%20molecular%20biology%207th%20ed%</a></p>
<b>Self-Study</b>	<ol style="list-style-type: none"> <li>1. Types of rotors</li> <li>2. Colorimetry – principle and applications</li> </ol>
<b>Recommended Texts</b>	<ol style="list-style-type: none"> <li>1. Keith Wilson , John Walker (2010) Principles and Techniques of Biochemistry and Molecular Biology (7th ed) Cambridge University Press</li> <li>2. David Sheehan (2009), Physical Biochemistry: Principles and Applications (2nd ed), Wiley-Blackwell</li> <li>3. David M. Freifelder (1982) Physical Biochemistry: Applications to Biochemistry and Molecular Biology, W.H. Freeman</li> <li>4. Rodney F. Boyer (2012), Biochemistry Laboratory: Modern Theory and techniques, (2nd ed), Prentice Hall</li> <li>5. Kaloch Rajan (2011), Analytical techniques in Biochemistry and Molecular Biology, Springer</li> <li>6. Segel I.H (1976) Biochemical Calculations (2nd ed), John Wiley and Sons</li> <li>7. Robyt JF (2015) Biochemical techniques: Theory and Practice (1st ed), CBS Publishers &amp; Distributors</li> </ol>

**Method of Evaluation:**

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

**Methods of assessment:**

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse (K4)** – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas.

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons

**Create (K6)** – Check knowledge in specific or offbeat situations. Discussion.

**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
<b>CO 1</b>	<b>S</b>	<b>L</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>L</b>	<b>L</b>	<b>S</b>	<b>S</b>	<b>M</b>
<b>CO 2</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>L</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>L</b>
<b>CO 3</b>	<b>S</b>	<b>M</b>	<b>L</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>L</b>
<b>CO 4</b>	<b>S</b>	<b>S</b>	<b>L</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>
<b>CO 5</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>M</b>

**S- Strong M-Medium L-Low      Strong:21      Medium: 21      Low:8**

<b>Course</b>	<b>CORE PRACTICAL I</b>
<b>Title of the Course:</b>	<b>LABORATORY COURSE ON BIOMOLECULES AND BIOCHEMICAL TECHNIQUES</b>
<b>Credits:</b>	<b>4</b>
<b>Pre-requisites</b>	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. To instill skill in students enabling them to apprehend the wider knowledge about principles and techniques to be employed for the biomolecules under investigation.</li> <li>2. To inculcate the knowledge of various isolation and purification techniques of macromolecules like DNA, RNA, Glycogen and Starch,</li> <li>3. To perform colorimetric estimations to quantify important metabolites like lactate and tryptophan and minerals like calcium and iron from various sources.</li> <li>4. To achieve training in subcellular fractionation and to identify them by markers.</li> <li>5 To achieve training in various chromatographic techniques.</li> <li>6. To perform the isolation and identification of the organelles of a cell using differential centrifugation.</li> <li>7. To perform phytochemical screening and quantification enabling them to give an insight on phytochemicals this will be useful for future research.</li> </ol>

<b>Course Outcomes</b>	<p><b>On successful completion of this course, students should be able to:</b></p> <p>After completion of the course, the students should be able to:</p> <p><b>CO1.</b>The student will be able to acquire knowledge and skill in the techniques used in the isolation, purification and estimation of different biomolecules that are widely employed in research (K1, K2, K4)</p> <p><b>CO2.</b>The students will get acquainted with Principle, Instrumentation and method of Performing UV absorption studies of DNA, Protein and interpreting the alteration occurred during the process of denaturation (K1,K2, K 3, K4).</p>
	<p><b>CO3.</b>The student will be fine-tune in handling the instruments like colorimeter, spectrophotometer and will be able to estimate the biomolecules and minerals from the given samples (K1,K2,K4,)</p> <p><b>CO4.</b> The student, in addition to acquiring skill in performing various biochemical techniques can also learn to detect presence of phytochemicals and quantify them in the plant sample. (K1,K2,K3,K4 &amp; K6)</p> <p><b>CO5.</b>The students will develop skill in analytical techniques like subcellular fractionation, Paper, Column and Thin layer Chromatography and the group experiments will enable them to build learning skills like team work, Problem solving, Communication ability. (K1, K2,K3,K4 &amp; K6)</p>
<b>Units</b>	
<b>I</b>	<p>Biochemical studies and estimation of macromolecules</p> <ol style="list-style-type: none"> <li>1. Isolation and estimation of glycogen from liver.</li> <li>2. Isolation and estimation of DNA from animal tissue.</li> <li>3. Isolation and estimation of RNA from yeast.</li> </ol>
<b>II</b>	<p>UV absorption</p> <ol style="list-style-type: none"> <li>1. Denaturation of DNA and absorption studies at 260nm.</li> <li>2. Denaturation of Protein and absorption studies at 280nm.</li> </ol>
<b>III</b>	<p>Colorimetric estimations</p> <ol style="list-style-type: none"> <li>1. Estimation of Pyruvate</li> <li>2. Estimation of tryptophan.</li> </ol>
<b>IV</b>	<p>Estimation of minerals</p> <ol style="list-style-type: none"> <li>1. Estimation of calcium</li> <li>2. Estimation of iron</li> </ol>



<b>V</b>	<b>Plant Biochemistry</b> 1. Qualitative analysis Phytochemical screening 2. Estimation of Flavonoids -Quantitative analysis
<b>VI</b>	<b>Group Experiments</b> 1. Fractionation of sub-cellular organelles by differential centrifugation-Mitochondria and nucleus 2. Identification of the separated sub-cellular fractions using marker enzymes (any one) 3. Separation and identification of lipids by thin layer chromatography.. 4. Separation of plant pigments from leaves by column chromatography 5. Identification of Sugars by Paper Chromatography 6. Identification of Amino acids by Paper Chromatography
<b>Reading List (Print and Online)</b>	1. <a href="https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion">https://www.researchgate.net/publication/313745155_Practical_Biochemistry_A_Student_Companion</a> 2. <a href="https://doi.org/10.1186/s13020-018-0177-x">https://doi.org/10.1186/s13020-018-0177-x</a> 3. <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5368116/</a> 4. <a href="https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf">https://www.life.illinois.edu/biochem/455/Lab%20exercises/2Photometry/spectrophotometry.pdf</a> 5. <a href="https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol-content-in-mimusops-elengi-linn/?view=fulltext">https://ijpsr.com/bft-article/determination-of-total-flavonoid-and-phenol-content-in-mimusops-elengi-linn/?view=fulltext</a> 6. <a href="https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf">https://skyfox.co/wp-content/uploads/2020/12/Practical-Manual-of-Biochemistry.pdf</a>
<b>Self-Study</b>	1. Laboratory Safety Rules, Requirements and Regulations. 2. Preparation of standard solutions and reagent
<b>Books Recommended</b>	1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd 2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers 3. Varley H (2006) Practical Clinical Biochemistry (6th ed) , CBS Publishers 4. O. Debiyi and F. A. Sofowora, (1978 )“Phytochemical screening of medical plants,” Iloyidia, vol. 3, pp. 234–246, 5. Prof. Sarin A. Chavhan, Prof. Sushilkumar A. Shinde (2019) A Guide to Chromatography Techniques Edition:1 6. Analytical techniques in Biochemistry and Molecular Biology; Katoch, Rajan. Springer (2011)

**Method of Evaluation:**

Test I	Test II	End Semester Examination	Total	Grade
20	20	40	100	

**Methods of assessment:**

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse (K4)**- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

**Create (K6)**- Check knowledge in specific or offbeat situations, Discussion.

**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
<b>CO 1</b>	S	S	S	S	M	S	L	S	M	S
<b>CO 2</b>	S	S	S	S	M	S	L	S	M	S
<b>CO 3</b>	S	S	S	S	M	S	M	S	M	S
<b>CO 4</b>	S	S	S	S	S	S	S	S	S	S
<b>CO 5</b>	S	S	S	S	S	S	S	S	S	S

**S- Strong**

**M-Medium**

**L-Low**

**Strong:41**

**Medium: 7**

**Low:2**

<b>Course</b>	<b>CORE ELECTIVE PAPER -I</b>
<b>Title of the Course:</b>	<b>MICROBIOLOGY &amp; IMMUNOLOGY</b>
<b>Credits:</b>	<b>3</b>
<b>Pre-requisites, if any:</b>	The student should possess basic knowledge about microorganisms, types and their general characteristics. The students are also expected to possess basic understanding about the process of infection, immunological defence and pathological outcomes, if any.
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. To appreciate the classification of microorganisms based on their structure, size and shape with an insight into the ancient scriptures about microbes.</li> <li>2. To understand the role of microorganisms in environment and also to learn the culture conditions.</li> <li>3. To recognize the possible contamination of foods by microorganisms, to learn about counteracting preservative measures and to know about probiotic nature of microorganisms.</li> <li>4. To gain knowledge on pathogenic mediation by microorganisms and preventive measures as well.</li> <li>5. To comprehend the features of antimicrobial agents, their mechanism of action along with the side effects and also to explore natural remedial measures against microbes.</li> <li>6. To be able to exploit the various features of microorganisms for the beneficial industrial production.</li> </ol>
<b>Course Outcomes</b>	<p>After completion of the course, the students should be able to:</p> <p><b>CO1.</b> To classify (by both ancient and modern modes) different types of microorganisms and explain life cycle of the microbes (K1, K2 &amp; K5)</p> <p><b>CO2.</b> To recognize the microorganisms involved in decay of foods and will be able to apply various counteracting measures. The students also will be able to relate the role of certain beneficial microbes in day-to-day's food consumption. (K1, K2 &amp; K4)</p> <p><b>CO3.</b> To understand the common pathogenic bacterial and fungi that cause toxic effects and also will be able to employ curative measures. (K1 &amp; K2)</p> <p><b>CO4.</b> To analyse various features of wide variety of antimicrobial agents along with their mode of action, in addition, being able to apprehend the valuable potentials of traditional and easily available herbs. (K2, K5 &amp; K6)</p> <p><b>CO5.</b> To apply knowledge gained in production of industrially important products as both pharmaceutical and nutraceutical. (K2, K4 &amp; K5)</p>
<b>Units</b>	

<b>I</b>	Taxonomical classification - bacteria, viruses (DNA, RNA), algae, fungi and protozoa. Distribution and role of microorganisms in soil, water and air. classification of microbes, lytic cycle and lysogeny. Types of culture media, isolation of pure culture, growth curve and the measurement of microbial growth.
<b>II</b>	Contamination and spoilage of foods – cereals, cereal products, fruits, vegetables, meat, fish, poultry, eggs, milk and milk products. General principles of traditional and modern methods of food preservation - Removal or inactivation of microorganisms, boiling, steaming, curing, pasteurization, cold processing, freeze drying, irradiation, vacuum packing, control of oxygen and enzymes. Microbes involved in preparation of fermented foods - cheese, yoghurt, curd, pickles, rice pan cake, appam, ragi porridge (□□□□□□□□ □□□□ ) and bread.
<b>III</b>	Food poisoning- bacterial food poisoning, <i>Salmonella</i> , <i>Clostridium botulinum</i> (botulism), <i>Staphylococcus aureus</i> , fungal food poisoning – aflatoxin, food infection – <i>Clostridium</i> , <i>Staphylococcus</i> and <i>Salmonella</i> . Pathogenic microorganisms, <i>E. coli</i> , <i>Pseudomonas</i> , <i>Klebsilla</i> , <i>Streptococcus</i> , <i>Haemophilus</i> , & <i>Mycobacterium</i> , causes, control, prevention, cure and safety. Food microbiological screening- Real time PCR, ELISA, Hazard analysis critical control point (HACCP)
<b>IV</b>	Antimicrobial chemotherapy, General characteristics of antimicrobial agents. Mechanism of action – sulfonamides, sulphones and PAS. Penicillin, streptomycin- spectra of activity, mode of administration, mode of action, adverse effects and sensitivity test., Antiviral and antiretroviral agents, Antiviral RNA interference, natural intervention (Natural immunomodulators routinely used in Indian medical philosophy).
<b>V</b>	Immune system- definition and properties. Cells of the immune system – neutrophils, eosinophils, basophils, mast cells, monocytes, macrophages, dendritic cells, natural killer cells, and lymphocytes (B cells and T cells). Lymphoid organs- Primary and Secondary; structure and functions. Antigens and Complement System: definition, properties- antigenicity and immunogenicity, antigenic determinants and haptens. Antigen - antibody interactions - molecular mechanism of binding. Affinity, avidity, valency, cross reactivity and multivalent binding. Immunoglobulins & Immune Response: Structure, classes and distribution of antibodies. Antibody diversity. Immune system in health & disease, Transplantation immunology- graft rejection and HLA antigens. Immunological techniques and its application.

<b>Reading List (Print and Online)</b>	<a href="https://www.ijam.co.in/index.php/ijam/article/view/1326">https://www.ijam.co.in/index.php/ijam/article/view/1326</a> (Krumi (Microorganisms) in Ayurveda- a critical review) Virtual Lectures in Microbiology and Immunology, University of Rochester <a href="https://www.frontiersin.org/articles/10.3389/fphar.2020.578970/full#h9">https://www.frontiersin.org/articles/10.3389/fphar.2020.578970/full#h9</a> <a href="https://www.frontiersin.org/articles/10.3389/fmicb.2018.02151/full">https://www.frontiersin.org/articles/10.3389/fmicb.2018.02151/full</a> <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7559905/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7559905/</a>
<b>Self-Study</b>	1. Microbial infections and gut microbiome with relevance to <i>tridoshas</i> 2. Microbial population and pH variations in different dairy products.
<b>Recommended Texts</b>	1. Michael J. Pelczar Jr. (2001) Microbiology (5th ed), McGraw Hill Education (India) Private Limited 2. Frazier WC, Westhoff DC, Vanitha NM (2010) Food Microbiology (5 <sup>th</sup> ed), McGraw Hill Education (India) Private Limited 3. Willey J and Sherwood L (2011) Prescott's Microbiology (8 <sup>th</sup> ed) McGraw Hill Education (India) 4. Ananthanarayanan, Paniker and Arti Kapil (2013) Textbook of Microbiology (9 <sup>th</sup> ed) Orient BlackSwan 5. Judy Owen, Jenni Punt Kuby (2013) Immunology (Kindt, Kuby Immunology) (7th ed) W. H. Freeman & Co 6. Brooks GF and Carroll KC (2013) Jawetz Melnick & Adelbergs Medical Microbiology, (26 <sup>th</sup> ed) McGraw Hill Education 7. Greenwood D (2012) Medical Microbiology, Elsevier Health

#### Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

#### Methods of assessment:

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Observe, Explain.

**Analyse (K4)**- Finish procedure in stepwise manner, Differentiation between various ideas, Map knowledge

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

**Create (K6)**- Check knowledge in specific or offbeat situations, Discussion, Debating, Presentation

**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
<b>CO 1</b>	S	L	S	S	S	S	M	S	S	S
<b>CO 2</b>	S	S	S	S	S	M	L	M	S	S
<b>CO 3</b>	S	M	M	S	M	M	M	M	L	M
<b>CO 4</b>	S	M	M	M	M	M	M	S	S	S
<b>CO 5</b>	S	L	S	S	M	L	L	S	S	S
<b>S- Strong</b>		<b>M-Medium</b>		<b>L-Low</b>		<b>Strong:27</b>		<b>Medium: 17</b>		<b>Low:6</b>

<b>Course</b>	<b>CORE ELECTIVE PAPER II</b>
<b>Title of the Course:</b>	<b>ENERGY AND DRUG METABOLISM</b>
<b>Credits:</b>	<b>3</b>
<b>Pre-requisites</b>	Basic knowledge on biochemical reactions such as addition, deletion, rearrangement, transfer and breaking of bonds
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. Familiarize on concepts of enthalpy, entropy, free energy, redox system, biological oxidation and high energy compounds</li> <li>2. Provide an insight into the relationship between electron flow and phosphorylation</li> <li>3. Inculcate knowledge on processes involved in converting light energy to chemical energy and associated food production by autotrophs</li> <li>4. Provide a platform to understand the versatile role of Krebs cycle, transport of NADH across mitochondrial membrane and energetics</li> <li>5. Educate on the various phases xenobiotic metabolism</li> </ol>
<b>Course Outcomes</b>	<p><b>On successful completion of this course, students should be able to:</b></p> <p>After completion of the course, the students should be able to:</p> <p><b>CO1.</b> Appreciate the relationship between free energy and redox potential and will be able to justify the role of biological oxidation and energy rich compounds in maintaining the energy level of the system <b>(K1,K2,K3,K4)</b></p> <p><b>CO2.</b> Gain knowledge on role of mitochondria in the production of energy currency of the cell <b>(K1, K2, K5, K6)</b></p> <p><b>CO3.</b> Acquaint with the process of photosynthesis <b>(K1,K2,K5)</b></p> <p><b>CO4.</b> Comprehend on the diverse role of TCA cycle and the energy obtained on complete oxidation of glucose and fatty acid <b>(K1,K2,K4,K5)</b></p> <p><b>CO5.</b> Correlate the avenues available to metabolize the xenobiotics <b>(K1, K2,K4,K5)</b></p>
<b>Units</b>	
<b>I</b>	Thermodynamic- principles in biology- Concept of entropy, enthalpy and free energy change. Redox systems. Redox potential and calculation of free energy. Biological oxidation – Oxidases, dehydrogenases, hydroperoxidases, oxygenases. Energy rich compounds – phosphorylated and non-phosphorylated. High energy linkages.

<b>II</b>	Electron transport chain-various complexes of ETC, Q-cycle. Inhibitors of ETC. Oxidative phosphorylation-P/O ratio, chemiosmotic theory. Mechanism of ATP synthesis - role of F <sub>0</sub> -F <sub>1</sub> ATPase, ATP-ADP cycle. Inhibitors of oxidative phosphorylation ionophores, protonophores. Regulation of oxidative phosphorylation
<b>III</b>	Light reaction-Hills reaction, absorption of light, photochemical event. Photo ETC-cyclic and non-cyclic electron flow. Photophosphorylation-role of CF <sub>0</sub> -CF <sub>1</sub> ATPase. Dark reaction- Calvin cycle, control of C <sub>3</sub> pathway, and Hatch-Slack pathway (C <sub>4</sub> pathway), Photorespiration. Synthesis and degradation of starch
<b>IV</b>	Interconversion of major food stuffs. Energy sources of brain, muscle, liver, kidney and adipose tissue. Amphibolic nature of Citric acid cycle. Anaplerotic reaction. Krebs cycle, Inhibitors and regulation of TCA cycle. Transport of extra mitochondrial NADH – Glycerophosphate shuttle, malate aspartate shuttle. Energetics of metabolic pathways – glycolysis, (aerobic and anaerobic), citric acid cycle, beta oxidation
<b>V</b>	Activation of sulphate ions – PAPS, APS, SAM and their biological role. Metabolism of xenobiotics – Phase I reactions – hydroxylation, oxidation and reduction. Phase II reactions – glucuronidation, sulphation, glutathione conjugation, acetylation and methylation. Mode of action and factors affecting the activities of xenobiotic enzymes.
<b>Reading List (Print and Online)</b>	<ol style="list-style-type: none"> <li>1. <a href="https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch21/gibbs.php">https://chemed.chem.purdue.edu/genchem/topicreview/bp/ch21/gibbs.php</a></li> <li>2. <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7767752/#:~:text=The%20mitochondrial%20electron%20transport%20chain,cellular%20ATP%20through%20oxidative%20phosphorylation.">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7767752/#:~:text=The%20mitochondrial%20electron%20transport%20chain,cellular%20ATP%20through%20oxidative%20phosphorylation.</a></li> <li>3. <a href="https://www.researchgate.net/figure/Oxidative-phosphorylation-in-mitochondrial-electron-transport-chain-ETC-and-proton_fig1_230798915">https://www.researchgate.net/figure/Oxidative-phosphorylation-in-mitochondrial-electron-transport-chain-ETC-and-proton_fig1_230798915</a></li> <li>4. <a href="https://www.lyndhurstschools.net/userfiles/84/Classes/851/photosynthesis%20light%20&amp;%20dark%20reactions%20ppt.pdf?id=560837">https://www.lyndhurstschools.net/userfiles/84/Classes/851/photosynthesis%20light%20&amp;%20dark%20reactions%20ppt.pdf?id=560837</a></li> <li>5. <a href="https://bajan.files.wordpress.com/2010/05/amphibolic-nature-of-krebs-cycle.pdf">https://bajan.files.wordpress.com/2010/05/amphibolic-nature-of-krebs-cycle.pdf</a></li> <li>6. <a href="https://www.sciencedirect.com/topics/medicine-and-dentistry/xenobiotic-metabolism#:~:text=Xenobiotic%20metabolism%20can%20be%20defined,more%20readily%20excreted%20hydrophilic%20metabolites">https://www.sciencedirect.com/topics/medicine-and-dentistry/xenobiotic-metabolism#:~:text=Xenobiotic%20metabolism%20can%20be%20defined,more%20readily%20excreted%20hydrophilic%20metabolites</a></li> </ol>
<b>Self-Study</b>	<ol style="list-style-type: none"> <li>1. Calculation of K<sub>eq</sub> and G</li> <li>2. Interrelationship of carbohydrate, protein, and fat metabolism-role of acetyl CoA</li> </ol>



<b>Recommended Texts</b>	1. David L. Nelson and Michael M. Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H. Freeman 2. Robert K. Murray, Darryl K. Granner, Peter A. Mayes, and Victor W. Rodwell (2012), Harper's Illustrated Biochemistry, (29th ed), McGraw-Hill Medical 3. Metzler D.E (2003). The chemical reactions of living cells (2nd ed), Academic Press. 4. Zubay G.L (1999) Biochemistry, (4th ed), McGraw-Hill. 5. Devlin R.M (1983) Plant Physiology (4th ed), PWS publishers 6. Taiz L, Zeiger E (2010), Plant Physiology (5th ed), Sinauer Associates, Inc
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**Method of Evaluation:**

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

**Methods of assessment:**

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse (K4)**- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

**Create (K6)**- Check knowledge in specific or offbeat situations, Discussion.

**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	S	M	S	M	S	S	S	M
CO 2	S	S	S	S	S	S	S	S	S	S
CO 3	S	S	S	S	S	S	S	S	S	S
CO 4	S	M	S	M	S	M	S	S	S	L
CO 5	S	M	S	S	S	M	S	S	S	S
S-Strong		M-Medium		L-Low		Strong:41		Medium: 08		Low:01

## SEMESTER II

<b>Course</b>	<b>CORE PAPER III</b>
<b>Title of the Course:</b>	<b>ENZYMOLOGY</b>
<b>Credits:</b>	<b>5</b>
<b>Pre-requisites</b>	Basic knowledge about catalysis, kinetics and chemical reaction mechanisms.
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. Students will be introduced to the theory and practice of enzymology.</li> <li>2. Mechanisms of catalysis and factors affecting catalysis will be understood</li> <li>3. The kinetics of enzyme catalyzed reactions in the absence and presence of inhibitors will be studied and the options for applying enzymes and their inhibitors in medicine will be analyzed.</li> </ol>
	<ol style="list-style-type: none"> <li>4. Students will learn about the applications of enzymes in research, medicine, and industry, which will prepare them for careers in industrial and biomedical research.</li> <li>5. The control of metabolic pathways and cellular responses through enzyme regulation will be emphasized.</li> </ol>
<b>Course Outcomes</b>	<p><b>On successful completion of this course, students should be able to:</b></p> <p><b>CO1:</b> Describe the catalytic mechanisms employed by enzymes (K1, K2 &amp; K5)</p> <p><b>CO2:</b> Choose and use the appropriate methods to isolate and purify enzymes and check the purity of the enzyme .(K1,K2 , K3,K4 &amp; K5)</p> <p><b>CO3:</b> Analyze enzyme kinetic data graphically, calculate kinetic parameters, determine the mechanism of inhibition by a drug/chemical and analyze options for applying enzymes and their inhibitors in medicine (K1, K2, K3 &amp;K4)</p> <p><b>CO4:</b> Explain allosterism and cooperativity and differentiate Michaelis-Menten kinetics from sigmoidal kinetics. The role played by enzymes in the regulation of vital cellular processes will be appreciated. (K1, K2 , K5, K6)</p> <p><b>CO5:</b> Highlight the use of enzymes in industries and biomedicine (K1,K2 &amp; K3)</p>

Units	
<b>I</b>	<p>Introduction to enzymes and features of catalysis: A short history of the discovery of enzymes and how they became powerful biochemical tools. Holoenzyme, apoenzyme, cofactors, coenzyme, prosthetic groups, Classification and Nomenclature, Specificity of enzyme action-group specificity, absolute specificity, substrate specificity, stereochemical specificity. Active site, Identification of amino acids at the active site-trapping of ES complex, identification using chemical modification of amino acid side chains and by site-directed mutagenesis.</p> <p>Mechanisms of enzyme catalysis: acid-base catalysis, covalent catalysis, electrostatic catalysis, metal ion catalysis, proximity and orientation effects, Low barrier H-bonds, Structural flexibility Mechanism of action of chymotrypsin</p>
<b>II</b>	<p>Enzyme techniques: Isolation and purification of enzymes - Importance of enzyme purification, methods of purification- choice of source , extraction, fractionation methods-based on size or mass (centrifugation, gel filtration); based on polarity (ion-exchange chromatography, electrophoresis, isoelectric focusing, hydrophobic interaction chromatography); based on solubility (change in pH, change in ionic strength); based on specific binding sites (affinity chromatography) ,choice of methods, Criteria of purity of enzymes. Enzyme units - Katal, IU. Measurement of enzyme activity - discontinuous, continuous, coupled assays; stopped flow method and its applications. Isoenzymes and their separation by electrophoresis with special reference to LDH</p>
<b>III</b>	<p>Enzyme kinetics I: Thermodynamics of enzyme action, Activation energy, transition-state theory, steady-state kinetics &amp; pre-steady-state kinetics. Single substrate enzyme catalyzed reactions -assumptions, Michaelis-Menten and Briggs-Haldane kinetics, derivation of Michaelis-Menten equation . Double reciprocal (Lineweaver-Burk) and single reciprocal (Eadie -Hofstee) linear plots, their advantages and limitations. Analysis of kinetic data- determination of <math>K_m</math>, <math>V_{max}</math>, <math>k_{cat}</math>, and their physiological significance, Importance of <math>k_{cat}/K_m</math>. Enzyme inhibition: Irreversible inhibition. Reversible inhibition-Competitive, uncompetitive, noncompetitive, mixed and substrate inhibition. Michaelis -Menten equation in the presence of competitive, uncompetitive and non-competitive inhibitors. Therapeutic use of enzyme inhibitors-Aspirin, statins (irreversible inhibitors), Methotrexate (competitive inhibitor), Etoposide (non-competitive inhibitor), camptothecin (uncompetitive inhibitor).</p>

IV	Enzyme kinetics II: Allosteric enzymes: Cooperativity, Sigmoidal kinetics taking ATCase as an example. Regulation of amount and catalytic activity by - extracellular signal, transcription, stability of mRNA, rate of translation and degradation, compartmentation, pH, temperature, substrate concentration, allosteric effectors, covalent modification. Regulation of glycogen synthase and glycogen phosphorylase. Feedback inhibition-sequential, concerted, cumulative, enzyme-multiplicity with examples.
	Bi - Substrate reactions: Single Displacement reactions (SDR) (Ordered and Random bi bi mechanisms), Double Displacement reactions (DDR) (Ping pong mechanism), Examples, Cleland's representation of bisubstrate reactions.
V	Enzyme technology: Immobilization of enzymes – methods - Reversible immobilization (Adsorption, Affinity binding), Irreversible immobilization (Covalent coupling, Entrapment and Microencapsulation, Crosslinking, Advantages and Disadvantages of each method, Properties of immobilized enzymes,. Designer enzymes-ribozymes and deoxyribozymes, abzymes, synzymes. Enzymes as therapeutic agents-therapeutic use of asparaginase and streptokinase. Application of enzymes in industry- Industrial application of rennin, lipases, lactases, invertase, pectinases, papain.
<b>Reading List (Print and Online)</b>	<p><b>Enzymes</b>   MIT OpenCourseWare   Free Online Course Materials  <a href="https://ocw.mit.edu/high-school/biology/exam-prep/chemistry-of-life/enzymes/">https://ocw.mit.edu/high-school/biology/exam-prep/chemistry-of-life/enzymes/</a></p> <p><b>Enzymology</b>  <a href="https://onlinecourses.swayam2.ac.in/cec20_bt20/preview">https://onlinecourses.swayam2.ac.in/cec20_bt20/preview</a>  <a href="https://mooc.es/course/enzymology/">https://mooc.es/course/enzymology/</a></p> <p><b>The active site of enzymes</b>  <a href="https://dth.ac.in/medical/courses/biochemistry/block-1/1/index.php">https://dth.ac.in/medical/courses/biochemistry/block-1/1/index.php</a></p> <p><b>Enzymes and Enzyme Kinetics</b>  <a href="https://www.lecturio.com/medical-courses/enzymes-and-enzyme-kinetics.course#/">https://www.lecturio.com/medical-courses/enzymes-and-enzyme-kinetics.course#/</a></p> <p>Mechanistic enzymology in drug discovery: a fresh perspective  <a href="https://www.nature.com/articles/nrd.2017.219">https://www.nature.com/articles/nrd.2017.219</a></p> <p>Enzyme Biosensors for Biomedical Applications: Strategies for Safeguarding Analytical Performances in Biological Fluids  <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4934206/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4934206/</a></p>
<b>Self-Study</b>	<p>1.Mechanistic enzymology in drug discovery</p> <p>2. Enzyme Biosensors for Biomedical Applications</p>

<b>Recommended Texts</b>	<p>1.Enzymes: Biochemistry, Biotechnology and Clinical chemistry, 2nd edition, 2007, Palmer T and Bonner P; Affiliated- East West press private Ltd, New Delhi</p> <p>2.Fundamentals of Enzymology, 3rd edition, 2003, Price NC and Stevens L; Oxford University Press, New York</p> <p>3.Voet's Biochemistry, Adapted ed, 2011,Voet,D and Voet JG; Wiley, India</p> <p>4.Lehninger Principles of Biochemistry, 8th edition, 2021, .Nelson DL and Cox MM; WH Freeman &amp; Co, New York</p> <p>5. Biochemistry, Berg JM, Stryer L, Gatto,G, 8th ed, 2015;WH Freeman &amp; Co., New York.</p> <p>6.Enzyme Kinetics and Mechanism; Cook PF, Cleland W, ;2007; Garland Science, London</p>
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### Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

**Methods of assessment:**

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse (K4)-** Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

**Create (K6)-** Check knowledge in specific or offbeat situations, Discussion.

### Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	M	S	L	M	S	L	S	S	M
CO 2	S	S	S	S	M	M	L	S	S	S
CO 3	S	S	S	S	M	M	M	S	S	S
CO 4	S	S	S	S	M	M	M	S	S	S
CO 5	S	S	S	S	M	L	M	S	S	S
S-Strong		M-Medium		L-Low		Strong:33		Medium: 13		Low:04

<b>Course</b>	<b>CORE PAPER IV</b>
<b>Title of the Course:</b>	<b>CELLULAR METABOLISM</b>
<b>Credits:</b>	<b>5</b>
<b>Pre-requisites</b>	Basic knowledge on biochemical reactions such as addition, deletion, rearrangement, transfer and breaking of bonds
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. Familiarize on blood glucose homeostasis</li> <li>2. Provide an insight into the metabolic path way of glycogen, glycoprotein, mucopolysaccharide and peptidoglycan with clinical correlation wherever required</li> <li>3. Inculcate knowledge on nucleotide metabolism and disorders associated with it</li> <li>4. Provide a platform to understand the versatile role of PLP in amino acid degradation, formation of specialized products and disorders associated with ammonia detoxification</li> <li>5. Educate on heme and sulphur metabolism with associated clinical manifestation</li> </ol>
<b>Course Outcomes</b>	<p><b>On successful completion of this course, students should be able to:</b></p> <p>After completion of the course, the students should be able to:</p> <p><b>CO1.</b> Appreciate the modes of synthesis and degradation of glucose and will be able to justify the pros and cons of maintain the blood sugar level (<b>K1, K2, K5</b>)</p> <p><b>CO2.</b> Gain knowledge on polysaccharide metabolism and glycogen storage disease (<b>K1, K2, K5</b>)</p> <p><b>CO3.</b> Acquaint with the making and braking of nucleotides (<b>K1,K2,K4</b>)</p> <p><b>CO4.</b> Differentiate the diverse reaction a particular amino acid can experience (<b>K1,K2,K3</b>)</p> <p><b>CO5.</b> Correlate the disturbance of metabolic reactions to clinical manifestations with reference to heme and sulphur metabolism (<b>K1, K2, K4, K5</b>)</p>
<b>Units</b>	

<b>I</b>	Glycolysis – aerobic and anaerobic, inhibitors, and regulation. Feeder pathway- entry of hexoses into glycolysis, Galactosemia, fructosuria, Pyruvate dehydrogenase complex-mechanism and regulation. Glyoxalate cycle and its regulation. Gluconeogenesis- source, key enzymes, reaction sequence and its regulation. Blood glucose homeostasis and the role of hormones. Pentose phosphate pathway-significance and its regulation. Metabolism of glycogen and its regulation. Biosynthesis of N-linked and O-linked glycoproteins, mucopolysaccharides, Chondroitin sulphate.
<b>II</b>	Oxidation of fatty acids-oxidation of saturated and unsaturated fatty acids ( $\alpha$ , $\beta$ & $\omega$ oxidation) Oxidation of fatty acids with odd and even numbered carbon atoms. Regulation of $\beta$ oxidation. Ketogenesis and its regulation. Biosynthesis of fatty acid–saturated and unsaturated, chain elongation, regulation. Biosynthesis of prostaglandins, thromboxanes and leukotrienes and hydroxyl eicosanoic acids. Biosynthesis and degradation of triacylglycerol, phosphoglycerol lipids-lecithin, cephalin, plasmalogens and phosphatidyl inositol, Sphingolipid-sphingomyelin, cerebroside, sulfatides, and gangliosides. Cholesterol biosynthesis and its regulation. Lipoprotein metabolism-chylomicrons, VLDL, HDL and LDL.
<b>III</b>	Metabolism of nucleotides- <i>De novo</i> synthesis and salvage pathways of purine and pyrimidine nucleotides. Regulation and inhibitors of nucleotide biosynthesis. Role of ribonucleotide reductase and its regulation. Degradation of purine and pyrimidine nucleotides.
<b>IV</b>	Biosynthesis of non- essential amino acids.- Role and biological significance of glutamate dehydrogenase, glutamine and asparagine synthetase, lysine, proline and phenylalanine hydroxylase. Interconversion of amino acids - proline to glutamate, methionine to cysteine, serine to glycine. Biosynthesis of spermine and spermidine. Degradation of amino acids –glucogenic and ketogenic amino acids. Formation of acetate from leucine and aromatic amino acid, pyruvate from cysteine, threonine and hydroxy proline, $\alpha$ -keto glutarate from histidine and proline.
<b>V</b>	Biosynthesis and degradation of heme. Jaundice-classification, Sulpho transferases and their biological role-rhodanases, sulphatases , 3-mercapto pyruvate sulphur transferases. Mucopolysaccharidoses - Hunter syndrome, Sanfilippo syndrome and Maroteaux-Lamy syndrome. Oxidation of cysteine to sulphate and inter conversion of sulphur compounds.

<b>Reading List (Print and Online)</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.embopress.org/doi/full/10.1038/msb.2013.19">https://www.embopress.org/doi/full/10.1038/msb.2013.19</a></li> <li>2. <a href="https://people.wou.edu/~guralnl/450Glycogen%20metabolism.pdf">https://people.wou.edu/~guralnl/450Glycogen%20metabolism.pdf</a></li> <li>3. <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243375/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3243375/</a></li> <li>4. <a href="https://www.researchgate.net/publication/334458898_Urea_Cycle">https://www.researchgate.net/publication/334458898_Urea_Cycle</a></li> <li>5. <a href="https://www.researchgate.net/publication/51233381_Heme_biosynthesis_and_its_regulation_Towards_understanding_and_improvement_of_heme_biosynthesis_in_filamentous_fungi">https://www.researchgate.net/publication/51233381_Heme_biosynthesis_and_its_regulation_Towards_understanding_and_improvement_of_heme_biosynthesis_in_filamentous_fungi</a></li> <li>6. <a href="https://www.researchgate.net/publication/349746691_Microbial_Sulfur_Metabolism_and_Environmental_Implications">https://www.researchgate.net/publication/349746691_Microbial_Sulfur_Metabolism_and_Environmental_Implications</a></li> </ol>
<b>Self-study</b>	<ol style="list-style-type: none"> <li>1. Cori's Cycle and Glucose- Alanine Cycle</li> <li>2. Coenzymes involved in Methanogenesis</li> </ol>
<b>Books Recommended</b>	<ol style="list-style-type: none"> <li>1. David L. Nelson and Michael M. Cox (2012) Lehninger Principles of Biochemistry (6th ed), W.H. Freeman</li> <li>2. Voet. D and Voet. J. G (2010) Biochemistry, (4th ed), John Wiley &amp; Sons, Inc.</li> <li>3. Metzler D. E (2003). The chemical reactions of living cells (2nd ed), Academic Press.</li> <li>4. Zubay G. L (1999) Biochemistry, (4th ed), McGraw-Hill.</li> <li>5. Textbook of Biochemistry with Clinical Correlations, 7th Edition, Thomas M. Devlin (Editor), Wiley</li> <li>6. Human Biochemistry – James M. Orten &amp; Otto W. Neuhau- 10th edn- The C. V. Mosby Company</li> </ol>

**Method of Evaluation:**

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

**Methods of assessment:**

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse (K4)**- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

**Create (K6)**- Check knowledge in specific or offbeat situations, Discussion.



**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
<b>CO 1</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>M</b>
<b>CO 2</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>M</b>
<b>CO 3</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
<b>CO 4</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>M</b>
<b>CO 5</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>M</b>	<b>S</b>	<b>S</b>	<b>S</b>	<b>S</b>
<b>S-Strong</b>		<b>M-Medium</b>		<b>L-Low</b>	<b>Strong: 35</b>		<b>Medium: 15</b>		<b>Low:00</b>	

<b>Course</b>	<b>CORE PRACTICAL - II</b>
<b>Title of the Course:</b>	<b>LABORATORY COURSE IN ENZYMOLOGY , MICROBIOLOGY AND CELL BIOLOGY</b>
<b>Credits:</b>	<b>4</b>
<b>Pre-requisites</b>	Knowledge on basic principles, Instrumentation of Biochemical techniques and metabolic reactions
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. To inculcate skill in students enabling them to apprehend the wider knowledge about principles and techniques to be employed for the assay of enzymes under investigation.</li> <li>2. To inculcate the knowledge of isolation and purification techniques of enzymes using alkaline phosphatase as an example</li> <li>3. To perform experiments to study the factors affecting enzyme activity</li> <li>4. To achieve training in assay of enzymes</li> <li>5. To achieve training in basic microbiological techniques – preparation of culture, sterilization and staining methods.</li> <li>6. To perform the blood grouping test and to prepare blood smear to study different types of blood cells</li> <li>7. To learn molecular biology techniques like Gel electrophoresis and Blotting techniques</li> <li>8. To introduce industrial visit so that students may be aware of actual need of the industry and various opportunities available</li> </ol>
<b>Course Outcomes</b>	<p><b>On successful completion of this course, students should be able to:</b></p> <p>After completion of the course, the students should be able to:</p> <p><b>CO1.</b> The student will be able to employ the relevant techniques for isolation and purification of enzymes and gain skill in kinetic studies which is essential for research activity (K1,K2, K4)</p> <p><b>CO2.</b> Student will acquire ability in performing enzyme assay, and explicate the methods that form the basis of enzyme characterization. (K1,K2,K4)</p> <p><b>CO3.</b> Learn the Basic concepts in microbiology and cell biology which will be helpful for interdisciplinary research work. (K1,K3,K4)</p> <p><b>CO4.</b> Students will be trained in separation techniques used in molecular Biology which will be supportive in their future research (K1,K3,K4 &amp; K6)</p> <p><b>CO5.</b> Industrial visits will provide the students with an opportunity to learn practically through interaction, working methods and employment practices. Students will have an exposure to Industrial standard and current work practices (K1,K2,K3,K4 &amp; K6)</p>

Units	
<b>I</b>	<p>Enzymology</p> <p>Alkaline Phosphatase</p> <ol style="list-style-type: none"> <li>Isolation of Alkaline Phosphatase from goat kidney.</li> <li>Checking the purity using SDS-PAGE</li> <li>Determination of optimum pH and temperature of alkaline phosphatase.</li> <li>Determination of specific activity and <math>K_m</math> of alkaline phosphatase.</li> <li>Effect of activators and inhibitors on the activity of alkaline phosphatase.</li> </ol> <p>Assay of enzymes</p> <ol style="list-style-type: none"> <li>Salivary Amylase</li> <li>Acid Phosphatase</li> </ol>
<b>II</b>	<p>Microbiology</p> <ol style="list-style-type: none"> <li>Safety measures and Good Laboratory Practices in microbiology laboratory</li> <li>Sterilization, Culture and inoculum preparation</li> <li>Staining of bacteria – Gram Staining</li> </ol>
<b>III</b>	<p>Physiology &amp; Cell Biology</p> <ol style="list-style-type: none"> <li>Test for blood grouping (Haemagglutination).</li> <li>Peripheral Blood smear – Staining and Interpretation</li> </ol>
<b>IV</b>	<p>Group Experiments</p> <ol style="list-style-type: none"> <li>Separation of proteins based on molecular weight by SDS PAGE</li> <li>Agarose gel electrophoresis of genomic DNA</li> </ol>
<b>V</b>	Industrial visit can be organised to students through Academia – Industry collaborative Program
<b>Reading List (Print and Online)</b>	<ol style="list-style-type: none"> <li><a href="https://www.researchgate.net/publication/337146254_Kinetic_studies_with_alkaline_phosphatase">https://www.researchgate.net/publication/337146254_Kinetic_studies_with_alkaline_phosphatase</a></li> <li><a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846332/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4846332/</a></li> <li><a href="https://www.ijsr.net/archive/v3i8/MDIwMTU0MDk=.pdf">https://www.ijsr.net/archive/v3i8/MDIwMTU0MDk=.pdf</a></li> <li><a href="https://www.researchgate.net/publication/349318898_ABC_of_Peripheral_smear">https://www.researchgate.net/publication/349318898_ABC_of_Peripheral_smear</a></li> <li><a href="https://ncdc.gov.in/WriteReadData/1892s/File608.pdf">https://ncdc.gov.in/WriteReadData/1892s/File608.pdf</a></li> <li><a href="https://www.ncbi.nlm.nih.gov/books/NBK562156/">https://www.ncbi.nlm.nih.gov/books/NBK562156/</a></li> </ol>
<b>Self-Study</b>	<ol style="list-style-type: none"> <li>Preparation of Buffers and pH measurement</li> <li>Michaelis-Menten equation and Lineweaver Burk plot</li> </ol>

<b>Books Recommended</b>	<ol style="list-style-type: none"> <li>1. David Plummer (2001) An Introduction to Practical Biochemistry (3rd ed) McGraw Hill Education (India) Private Ltd</li> <li>2. Jayaraman, J (2011), laboratory Manual in Biochemistry, New age publishers</li> <li>3. Fundamentals of Enzymology; 3rd Edn. Nicholas C. Price and Lewis Stevens, Oxford University Press (2012).</li> <li>4. Enzymes: A Practical Introduction to Structure, Mechanism, and Data Analysis; Robert A. Copeland, Wiley-VCH Publishers (2000).</li> <li>5. Cappuccino JG &amp; Sherman N (2005). Microbiology-A Laboratory Manual, Pearson Education Inc</li> <li>6. Practical Enzymology, Second Revised Edition: Hans Bisswanger, Wiley – Blackwell; 2 edition (2011)</li> </ol>
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### Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

### Methods of assessment:

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse (K4)**- Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

**Create (K6)**- Check knowledge in specific or offbeat situations, Discussion.

### Mapping with Programme Outcomes:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	S	S	M	S	L	S	M	S
CO 2	S	S	S	S	M	S	L	S	M	S
CO 3	S	S	S	S	M	S	M	S	M	S
CO 4	S	S	S	S	S	S	S	S	S	S
CO 5	S	S	S	S	S	S	S	S	S	S
S-Strong		M-Medium		L-Low		Strong: 41		Medium: 07		Low:02

<b>Course</b>	<b>CORE ELECTIVE PAPER –III</b>
<b>Title of the Course:</b>	<b>BIOSTATISTICS &amp; DATA SCIENCE</b>
<b>Credits:</b>	<b>3</b>
<b>Pre-requisites, if any:</b>	Basic knowledge of Statistics and Computer Applications
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. To summarize the data and to obtain its salient features from the vast mass of original data.</li> <li>2. To understand the concept of various measures of dispersion.</li> <li>3. To understand the concepts of sampling and learning test of significance.</li> <li>4. To understand the concept of various attributes and relate to biological studies.</li> <li>5. To gain knowledge in SPSS, a software package which gives a perfect graphical representation and appropriate result for the data that has been entered</li> </ol>
<b>Course Outcomes</b>	<p>After completion of the course, the students should be able to:</p> <p><b>CO1:</b> Concepts of statistical population and sample, variables and attributes. Tabular and graphical representation of data based on variables.(K1,K2,K3)</p> <p><b>CO2:</b> Conditions for the consistency' and criteria for the independence of data based on attributes. Measures of central tendency, Dispersion, Skewness and Kurtosis.(K1,K2,K3)</p> <p><b>CO3:</b> Learning different sampling methods and analysing statistical significance.(K1,K2,K3,K4)</p> <p><b>CO4:</b> Understanding students t test , ANOVA , Chi square test to analyse the significance of various research. (K1,K2,K3,K4)</p> <p><b>CO5:</b> Learning on data science, algorithm for machine learning, artificial intelligence and big data, their applications in clinical and pharma domain . (K1,K2,K3,K4.K6)</p>
<b>Units</b>	
<b>I</b>	Nature of biological and clinical experiments – Collection of data in experiment- Primary and secondary data. Methods of data collection. Classification and tabulation. Different forms of diagrams and graphs related to biological studies. Measures of Averages- Mean, Median, and mode. Use of these measures in biological studies.

<b>II</b>	Measures of Dispersion for biological characters – Quartile deviation, Mean deviation, Standard deviation and coefficient of variation. Measures of skewness and kurtosis. Correlation and regression – Rank correlation – Regression equation. Simple problems based on biochemical data.
<b>III</b>	Basic concepts of sampling- Simple random sample stratified sample and systemic sampling. Sampling distribution and standard error. Test of significance based on large samples. Test for mean, difference of means, proportions and equality of proportions.
<b>IV</b>	Small sample tests – Students‘t’ test for mean, difference of two way means, tests for correlation and regression coefficients. Chi-square test for goodness of a non independence of attributes. F test for equality of variances. ANOVA- one way and two way. Basic concept related to biological studies
<b>V</b>	Introduction to Data Science, Definition of data science, importance, and basic applications, Machine Learning Algorithms, Deep Learning, Artificial Neural Networks and their Application, Reinforcement Learning, Natural Language Processing Artificial Intelligence (AI), Data Visualization, Data Analysis, Optimization Techniques, Big Data, Predictive Analysis. Application of AI in medical, health and pharma industries.
<b>Reading List (Print and Online)</b>	<ol style="list-style-type: none"> <li>1. <a href="https://www.ibm.com/docs/en/SSLVMB_28.0.0/pdf/Accessibility.pdf">https://www.ibm.com/docs/en/SSLVMB_28.0.0/pdf/Accessibility.pdf</a></li> <li>2. <a href="https://pure.tue.nl/ws/portalfiles/portal/19478370/20160419_CO_Mzol_o.pdf">https://pure.tue.nl/ws/portalfiles/portal/19478370/20160419_CO_Mzol_o.pdf</a></li> <li>3. <a href="https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5453888/">https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5453888/</a></li> <li>4. <a href="https://home.ubalt.edu/ntsbarsh/excel/excel.htm">https://home.ubalt.edu/ntsbarsh/excel/excel.htm</a></li> <li>5. <a href="https://students.shu.ac.uk/lits/it/documents/pdf/analysing_data_using_sps.pdf">https://students.shu.ac.uk/lits/it/documents/pdf/analysing_data_using_sps.pdf</a></li> <li>6. <a href="https://www.ibm.com/support/pages/ibm-spss-statistics-28-documentation">https://www.ibm.com/support/pages/ibm-spss-statistics-28-documentation</a></li> </ol>
<b>Self-Study</b>	<ol style="list-style-type: none"> <li>1. Simple problems on probability, theoretical distributions, hypothesis testing</li> <li>2. Relationship between mean, median and mode pros and cons of the measures of central tendency and deviation</li> </ol>
<b>Recommended Texts</b>	<ol style="list-style-type: none"> <li>1. Zar, J.H. (1984) “Bio Statistical Methods”, Prentice Hall, International Edition</li> <li>2. Sundar Rao P. S.S., Jesudian G. &amp; Richard J. (1987), “An Introduction to Biostatistics”, 2nd edition, Prestographik, Vellore, India,.</li> <li>3. Warren, J; Gregory, E; Grant, R (2004), “Statistical Methods in Bioinformatics”, 1st edition, Springer</li> <li>4. Milton, J.S. (1992), “Statistical methods in the Biological and Health Sciences”, 2nd edition, Mc Graw Hill,</li> <li>5. Rosner, B (2005), “Fundamentals of Biostatistics”, Duxbury Press</li> <li>6. Introducing Data Science, Davy Cielan, Anro DB Meysman, Mohamed Ali.</li> </ol>

#### Method of Evaluation:

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

**Methods of assessment:**

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain

**Analyse (K4)** - Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons

**Create (K6)** - Check knowledge in specific or off beat situations, Discussion, Presentations

**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	S	S	M	S	L	S	S	S
CO 2	S	S	S	S	M	S	L	S	S	S
CO 3	S	S	S	S	S	S	M	S	S	S
CO 4	S	S	S	S	S	S	M	S	S	S
CO 5	S	S	S	S	S	S	M	S	S	S

**S-Strong**

**M-Medium**

**L-Low**

**Strong: 43**

**Medium: 05**

**Low:02**

<b>rse</b>	<b>ELECTIVE PAPER IV</b>
<b>Title of the Course:</b>	<b>BIOSAFETY, LAB SAFETY AND IPR</b>
<b>Credits:</b>	<b>3</b>
<b>Pre-requisites, if any:</b>	The student should have a basic knowledge of hazards associated with the handling of biological agents and importance of intellectual property from scientific research.
<b>Course Objectives</b>	<ol style="list-style-type: none"> <li>1. To assimilate the hazards associated with the handling of biological and chemical agents.</li> <li>2. To understand how to protect from the hazards by the implementation of various safety measures in biochemical laboratories.</li> <li>3. To implicate the importance of protecting the scientific intellect by filing patent and understand the various offices for filing and maintaining patents</li> <li>4. To understand the scope of patenting in biological research.</li> <li>5. To create an awareness of ethics associated with used of genetically modified organisms/cells and its rationale for use in living organisms.</li> </ol>
<b>Course Outcomes</b>	<p>After completion of the course, the students should be able to:</p> <p><b>CO1.</b> To understand and implement various aspects of biosafety and carry out risk assessment of products in biological research</p> <p><b>CO2.</b> Understand the basic concepts of ethics and safety that are essential for different disciplines of science and procedures involved and protection of intellectual property and related rights.</p> <p><b>CO3.</b> To appreciate the intellectual property rights and its implementation of the invention related to biological research.</p> <p><b>CO4.</b> To understand the statutory bodies that regulate the property rights and its validity in various countries.</p> <p><b>CO5.</b> Critique the ethical concerns associated with modern biotechnology processes and plan accordingly.</p>

<b>Units</b>	
<b>I</b>	Biosafety: Historical background; introduction to biological safety cabinets; primary containment for biohazards; biosafety levels; recommended biosafety levels for infectious agents and infected animals; biosafety guidelines - government of India, roles of IBSC, RCGM, GEAC etc. for GMO applications in food and agriculture; environmental release of GMOs; risk assessment; risk management and communication; national regulations and international agreements.



II	<p>Laboratory safety - Chemical, electrical and fire hazards; handling and manipulating human or animal cells and tissues, toxic, corrosive or mutagenic solvents and reagents; mouth pipetting, and inhalation exposures to infectious aerosols, Safe handling of syringe needles or other contaminated sharps, spills and splashes onto skin and mucous membranes. Health aspects; toxicology, allergenicity, antibiotic resistance.</p> <p>History of biosafety microbiology and molecular biology, Risk assessment, Personal protective equipment, Laboratory facilities and safety equipment, Disinfection, decontamination, and sterilization, Regulatory compliance, Laboratory security and emergency response and administrative controls.</p>
III	<p>Intellectual Property Rights (IPR): Introduction to patents, types of patents, process involved in patenting in India, trademarks, copyright, industrial design, trade secrets, traditional knowledge, geographical indications, history of national and international <b>C</b>outreaties and conventions on patents, WTO, GATT, WIPO, Budapest Treaty, Patent Cooperation Treaty (PCT) and TRIPS. Patent databases: Searching international databases; analysis and report formation. Indian Patent Act 1970; recent amendments; filing of a patent application; precautions before patenting disclosure/non-disclosure; procedure for filing a PCT application. The patentability of microorganisms-claims, Characterization and repeatability disposition in the culture collections, legal protection for plants and other higher organisms, new plant varieties by rights.</p>
IV	<p>Patent filing and infringement: Patent application- forms and guidelines, fee structure, time frames; types of patent applications: provisional and complete specifications; PCT and convention patent applications, International patenting-requirement, financial assistance for patenting-introduction to existing schemes; Publication of patents-gazette of India, status in Europe and US. Research Patenting: Patenting by researchers and scientists-University/organizational rules in India and abroad. Detailed information on patenting biological products, Case studies on patents (basmati rice, turmeric, neem etc.), and patent infringement.</p>
V	<p>Bioethics:</p> <p>Introduction to bioethics, human genome project and its ethical issues, genetic manipulations and their ethical issues, ethical issues in GMOs, foods and crops in developed and developing countries, environmental release of GMOs, ethical issues involved in stem cell research and use, use of animals in research experiments, animal cloning, human cloning and their ethical aspects, testing of drugs on human volunteers.</p>
<b>Self-Study</b>	<ol style="list-style-type: none"> <li>1. Review of drug patent documents</li> <li>2. Safety in biological research laboratories</li> </ol>

<b>Reading List (Print and Online)</b>	<ol style="list-style-type: none"> <li>1. V. Shree Krishna, (2007). Bioethics and Biosafety in Biotechnology, New Age International Pvt. Ltd. Publishers. (Unit III, Unit IV and Unit V)</li> <li>2. Deepa Goel, Shomini Parashar, (2013). IPR, Biosafety and Bioethics, Pearson. (Unit II)</li> <li>3. R. Ian Freshney, 2016. Culture of Animal Cells: A Manual of Basic Technique and Specialized Applications, 6th Ed, John Wiley &amp; Blackwell.</li> <li>4. BAREACT, Indian Patent Act 1970 Acts &amp; Rules, Universal Law Publishing Co. Pvt. Ltd., 2007. (Unit I)</li> </ol>
<b>Recommended Texts</b>	<ol style="list-style-type: none"> <li>1. Biosafety in Microbiological and Biomedical Laboratories, (2020) 6th Ed. (<a href="https://www.cdc.gov/labs/pdf/SF__19_308133-A_BMBL6_00-BOOK-WEB-final3.pdf">https://www.cdc.gov/labs/pdf/SF__19_308133-A_BMBL6_00-BOOK-WEB-final3.pdf</a>)</li> <li>2. Kankanala C., (2007), Genetic Patent Law &amp; Strategy, 1st Edition, Manupatra Information Solution Pvt. Ltd.,</li> </ol>

**Method of Evaluation:**

Test I	Test II	Assignment	End Semester Examination	Total	Grade
10	10	5	75	100	

**Methods of assessment:**

**Recall (K1)** - Simple definitions, MCQ, Recall steps, Concept definitions.

**Understand/ Comprehend (K2)** - MCQ, True/False, Short essays, Concept explanations, Short summary or overview.

**Application (K3)** - Suggest idea/concept with examples, Solve problems, Observe, Explain.

**Analyse (K4)** – Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas.

**Evaluate (K5)** - Longer essay/ Evaluation essay, Critique or justify with pros and cons

**Create(K6)** – Check knowledge in specific or offbeat situations. Discussion.

**Mapping with Programme Outcomes:**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10
CO 1	S	S	S	M	S	M	S	S	S	S
CO 2	S	S	S	L	M	M	S	S	S	S
CO 3	S	M	M	M	S	M	S	S	S	M
CO 4	S	M	M	L	S	L	S	S	S	M
CO 5	S	S	S	L	S	M	S	S	S	S

S-Strong

M-Medium

L-Low

Strong: 33

Medium: 13

Low:04

